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An Efficient Decision Making for Fertilization

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Abstract: *Farmers often have limited control over fertilizer use, but achieving higher yields and minimizing fertilizer loss requires competent guidance. To optimize fertilizer utilization, it is essential to provide farmers with the best practices for applying fertilizers. Rainfall plays a significant role in nutrient loss following fertilizer applications after each rainfall event. Ideally, moderate rainfall occurring at the right time aids in nutrient absorption and the dissolution of dry fertilizers within the soil's rooting zone. However, excessive rainfall can lead to undesirable outcomes such as nutrient runoff and accelerated leaching of vital elements like nitrogen (N), phosphorus (P), potassium (K), manganese (Mn), and boron (B) from the soil. This necessitates a comprehensive approach that considers rainfall patterns, crop fertility, and time-series data analysis. By employing an advanced version of the random forest algorithm, this project offers nutrient recommendations tailored to specific crops. The proposed method leverages historical rainfall data and crop fertility information to forecast the optimal quantity of nutrients required for different crops. By considering these factors, the project aims to enhance soil fertility, promote optimal crop growth conditions, and mitigate the risks of nutrient leaching and runoff. Ultimately, this approach serves as a valuable resource for farmers seeking to improve their agricultural practices and maximize crop yields while minimizing environmental impact.*

I. INTRODUCTION

Agriculture plays a crucial role in driving the economic growth of nations, and India is no exception. With a contribution of 17-18% to India's GDP, agriculture ranks second globally in terms of farm outputs. One of the key factors that determine successful agricultural production is the use of fertilizers. Fertilizers are essential as they replenish the nutrients that crops extract from the top layer of the soil. Without proper fertilization, there can be a significant reduction in crop yields.

However, the process of fertilization requires precision. Factors such as rainfall patterns and the specific nutrient requirements for different crops must be considered when applying fertilizers. This is where machine learning technology comes into play. By leveraging available data on crop fertility and rainfall, machine learning algorithms can provide valuable insights to farmers, helping them make informed decisions.

One such project utilizes the random forest algorithm, a popular machine learning technique, to address this problem. The project takes three inputs from the user: crop location, pH level, and other relevant information. By applying the random forest algorithm, the system predicts the optimal amount of nutrients required for the specific crop, as well as the best time to apply fertilizers.

To make this technology accessible to farmers, a website is built using Flask Python, a web framework that ensures compatibility across various platforms. This website serves as a platform where users can access the machine learning-based predictions and recommendations for their crops. It can be easily shared among farmers, allowing them to benefit from robust information about crop fertilization techniques and rainfall patterns.

II.IMPLEMENTATION MODEL

A. Flow of Project

Apredictive model for determining the nutrient requirements of crops was developed using the random forest algorithm. This model demonstrates satisfactory accuracy in predicting the necessary nutrients. To evaluate the algorithm, a set of eight features were utilized.

As depicted in Figure 1, the algorithm relies on user input, including the location, pH level, and crop type. The location information provided by the user is then utilized to access a Weather API. This API provides specific characteristics such as temperature, humidity, and rainfall data for the given location.

If the weather data indicates a possibility of heavy rainfall, a precautionary message is promptly displayed to the user, alerting them to the potential risks associated with excessive rainfall. Conversely, if the weather conditions are favourable, the proposed algorithm is implemented.

In essence, this predictive model and algorithm integrate user inputs, weather data, and the power of random forest to determine the ideal nutrient requirements for crops. By incorporating these insights, farmers can make informed decisions on when and how to apply fertilizers, optimizing crop yields while considering environmental factors.

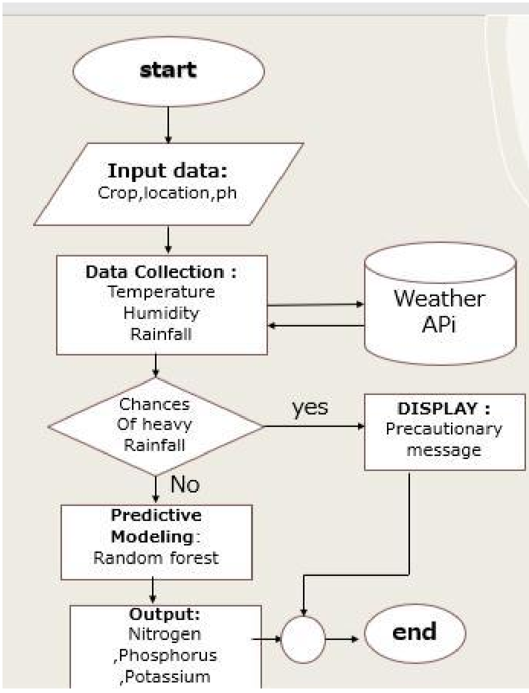

Figure 1: Flowchart

B. Block Diagram

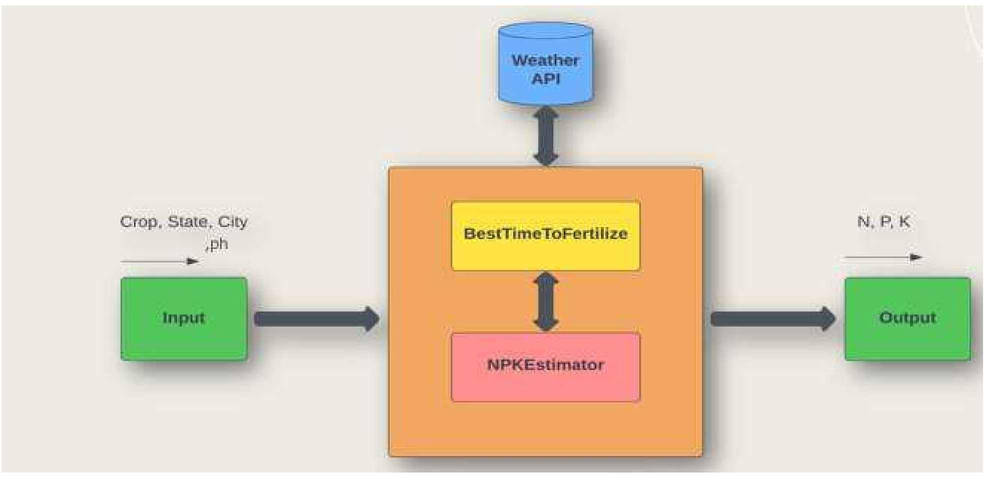

Figure 2: Block Diagram

System architecture is a conceptual model that defines the structure and behavior of the system. It comprises of the system components and the relationships describing how they work together to implement the overall system. The Figure shows the system's architecture and the various components added to them.

The description of each component from the block diagram and their major functionalities with respect to the Eco-Fertilization as a complete unit is described in the table below.

Sl No.	Block Name	Functions
1	Input	User provides data such as crop, state and city using drop-down menu and ph.
2	Weather API	Weather details like temerature, humidity, rainfall etc. is fetched from the weather API.
3	BestTimeToFertilize	This module provides the functionality to determine the best time to fertilize using fetched weather data and provides warning for heavy rain.
4	NPKEstimator	This module estimates the required ratio of NPK contents in the soil.
5	Output	Nitrogen, Phosphorus and Potassium content displayed on the website.

C. Implementation Algorithm

Random Forest Algorithm:

The random forest algorithm is a machine learning technique that is widely used for both classification and regression tasks. It is an ensemble learning method that combines the predictions of multiple decision trees to make more accurate and robust predictions.

In our project, we are utilizing the random forest (RF) algorithm, which consists of an ensemble of multiple decision trees. Each decision tree is trained on different subsets of the data, allowing for greater diversity and reducing the risk of overfitting.

To predict the values of N (nitrogen), P (phosphorus), and K (potassium), we will take two inputs: the crop type and the location. Based on these inputs, we will train three separate random forests, one for each nutrient. Each random forest will consist of 50 decision trees

To begin, we will divide our dataset into training and test datasets. The training dataset will contain 80% of the original data, while the remaining 20% will be allocated to the test dataset. This division ensures that we have a portion of data reserved for evaluating the performance of our model

Next, we will create three random forests, each containing 50 decision trees, to predict the values of N, P, and K. These decision trees will be trained using the training dataset, with each tree receiving a different subset of the data

Once the random forests are trained, we will make predictions by aggregating the outputs of all the decision trees. For each nutrient (N, P, K), the prediction will be obtained by calculating the mean of the predictions from all 50 decision trees in the corresponding random forest

By averaging the predictions of multiple decision trees, we obtain a more reliable and robust estimation of the nutrient values for the given crop and location.

In summary, our project utilizes the random forest algorithm to predict the values of N, P, and K based on the crop type and location inputs. The dataset is divided into training and test datasets, and three random forests, each consisting of 50 decision trees, are trained for each nutrient. The final predictions are obtained by averaging the outputs of the decision trees in each random forest.

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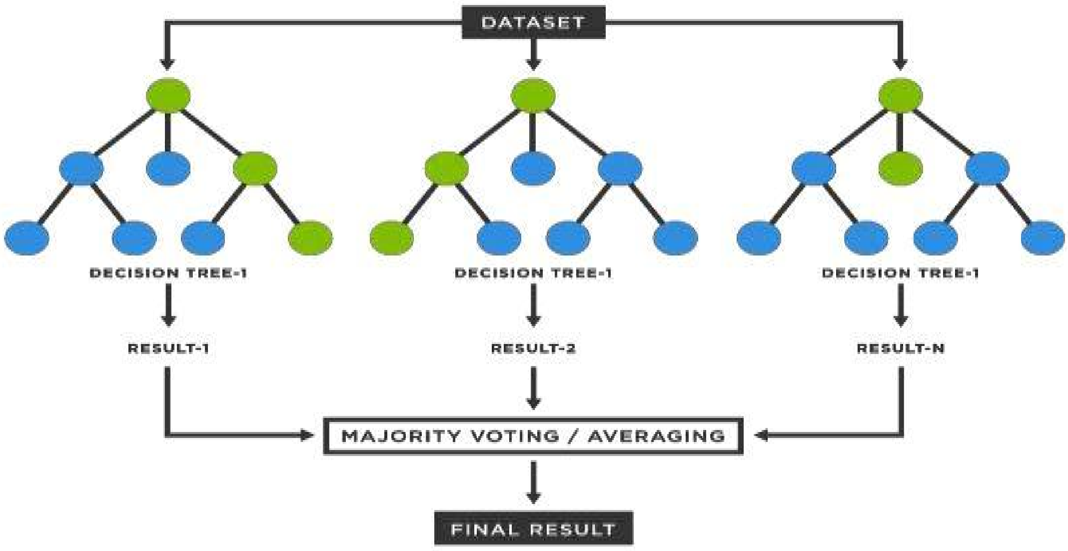

BEGIN:

Step 1: The dataset of size n = 2200 is divided into training and test dataset (where the raining set is 80% and the test set is 20% that is training set=1,760 and the test set=240).

Step 2: Apply random forest regression to each N, P and K (Nitrogen, Phosphorus & Potassium) value with n estimators=50 (n estimators is the number of decision trees).

Step 3: Train the N Label, P Label and K Label with the training dataset and dependent variable (Where the dependent variable is N for N Label, P forP Label and K for K Label).

Step 4: Each N Label, P Label and K Label generates a 50-decision tree as an output based on the training dataset.

END

Figure 3: Random Forest Algorithm

D. Input Features

- Crop: rice, cotton, etc.
- Temperature: temperature in degree Celsius
- Humidity: relative humidity in percentage
- Rainfall: rainfall in mm
- Ph: ph value of the soil

E.Output Features

- Label_N: ratio of Nitrogen content in soil
- Label_P: ratio of Phosphorous content in soil
- Label_K: ratio of Potassium content in soil

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III. RESULT

A user-friendly system called Eco-Fertilization has been developed as a website, offering convenient access and compatibility across multiple platforms. This system is designed to assist users by providing tailored recommendations regarding the optimal timing and precise amounts of nutrients required for a specific crop they input. Additionally, the system incorporates an alert mechanism that notifies users about heavy rainfall occurrences, enabling them to take appropriate actions in response. In summary, Eco-Fertilization's website interface ensures ease of use and offers personalized guidance for crop fertilization while also providing timely alerts for heavy rainfall events.

Figure 4: Homepage of Eco-Fertilization

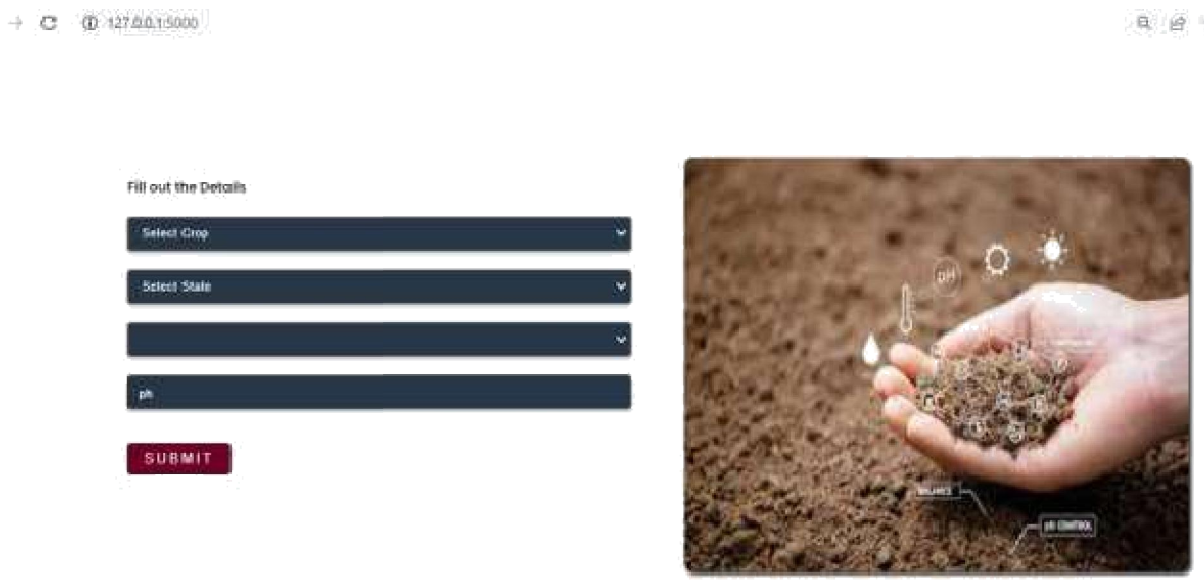

Figure 5: Input Details

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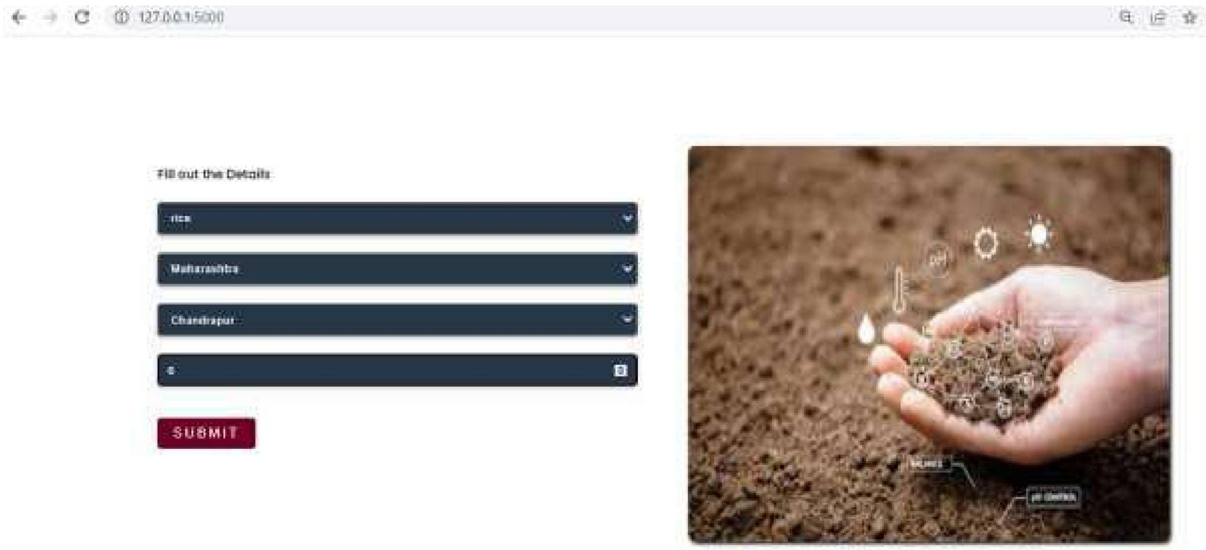

Figure 6: Details filled using the drop-down menu

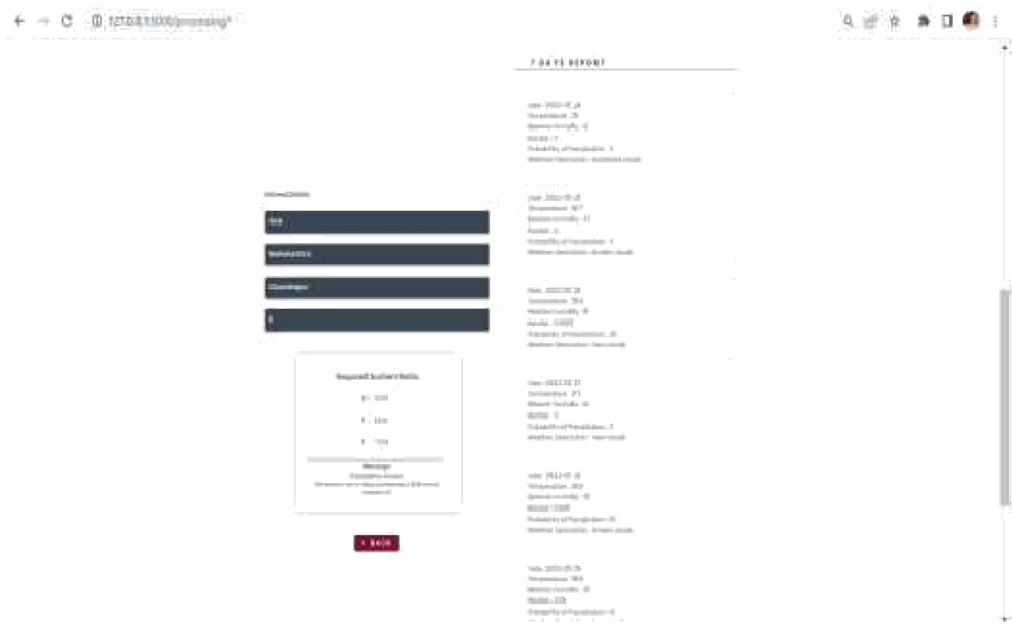

Figure 7: Output with seven days of weather forecasts & alerts/message

IV.CONCLUSION

The model successfully achieves an impressive accuracy rate of 92% for its predictive model, signifying its effectiveness as a valuable tool. It offers valuable insights into the optimal utilization and appropriate quantities of nutrients necessary for crops to ensure satisfactory growth and productivity, taking into account the prevailing weather conditions. Furthermore, the paper introduces a feature that provides weather alerts and messages, which are prominently displayed in the application's output in case of unfavorable weather conditions. It is worth noting that with advancements in technology, there is potential for further enhancements to improve the accuracy of the system even more. In summary, the project presents a robust model with high accuracy and the potential for continued development to refine its performance.

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